

## ACO160EVK Audio-to-Synth System

- Direct audio pitch to DCO square/sawtooth/sine oscillator output
- Low-latency MIDI out with included STM32F100C4 uC
- 1V/octave pitch CV output
- Zero-ripple envelope follower with eight rate settings
- Modulation CV input with +/-2 octave range in semitone resolution
- Gate output with user-configurable threshold
- 25Hz-5.2kHz frequency tracking range
- Hard sync square wave oscillator from 10Hz-10kHz generated by uC

### Applications

- Real-time pitch-to-MIDI using virtually any monophonic audio source
- Audio-controlled synthesizers
- Pitch-to-CV converters
- Pitch-dependent audio processing
- Harmonizers
- Guitar and other instrument effects/stompboxes

### Description

The ACO160EVK Audio-to-Synth system is an evaluation system for the ACO160 audio-controlled oscillator, an ultra-low latency, low-power frequency-tracking oscillator suitable for audio-controlled music synthesizer applications. The ACO160 contains a fundamental frequency detector based on dual switched-capacitor peak detectors with frequency-dependent decay time for ultra-wide detection range, ultrasonic analog oscillator and frequency tracking engine that forces the analog oscillator to run at 8192 times the frequency of the incoming audio signal detected at the input. This ultrasonic analog oscillator is then divided back down to

audio range using programmable dividers that are controlled by the harmony CV input and which cover a +/-2 octave range with semitone precision over the entire range.

Additionally, the ACO160 features an integrated switched-capacitor envelope follower which exhibits zero ripple, even for the lowest frequency signals the chip can detect (down to 25Hz). An integrated gate generation comparator has the envelope signal wired to its positive input and allows the user to set the voltage on the negative input. This voltage functions as the gate threshold and generates a rail-to-rail gate CV output.

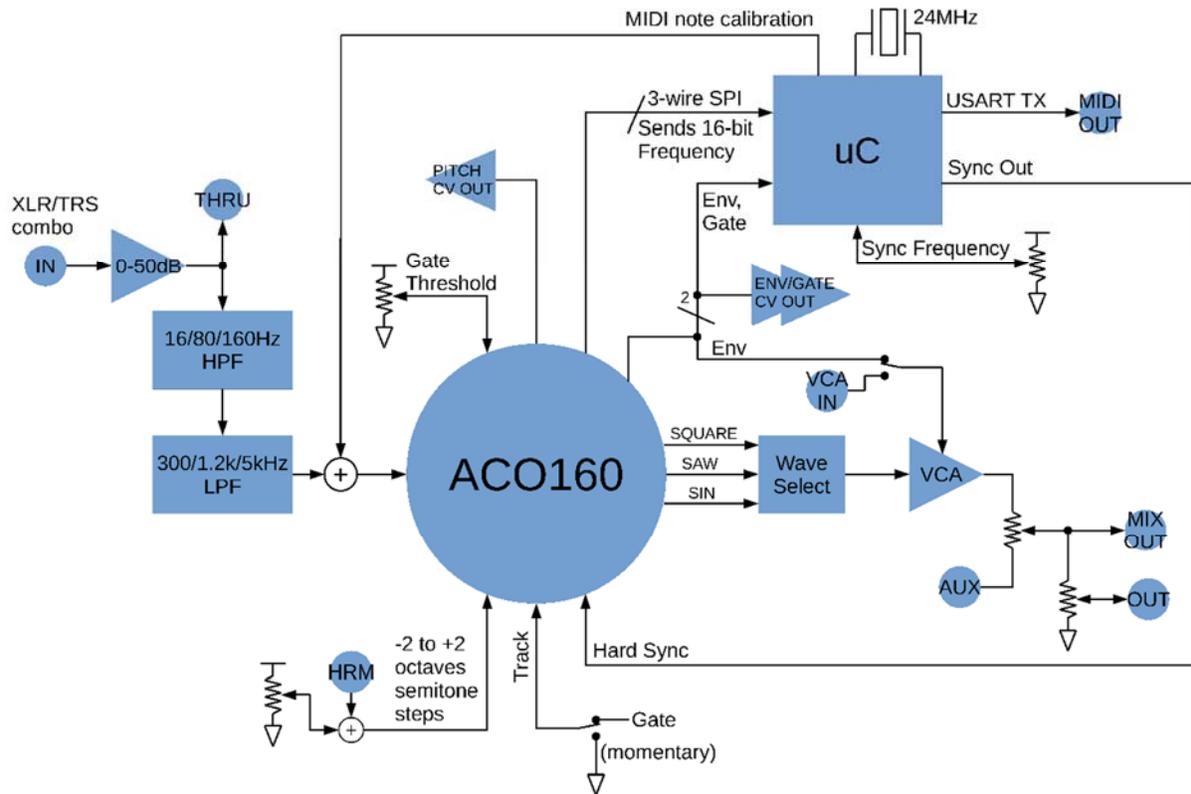
The ACO160EVK additionally includes a balanced preamp with combo XLR + ¼" jack input with 0-50dB gain, adjustable high-pass and low-pass filters for improved frequency detection (if needed) in front of the ACO160 chip, a VCA controlled either by the built-in envelope follower or by an external source, an auxiliary mixer to mix another synth voice after the VCA, and a STM32F100C4 micro-controller to convert the frequency, envelope and gate information provided by the ACO160 chip into MIDI commands to control digital synthesizers.

The ACO160EVK is meant to assist analog or digital synth manufacturers with designing products using its unique ACO technology and is not intended to serve as a finished consumer product.

### Ordering Information

Part Number	Package	Size
ACO160EVK	PCB	140mm x 120mm

Block Diagram of ACO160EVK Audio-to-Synth Evaluation System



ACO160EVK Inputs and Outputs

Name	Direction	Description
PSU Input	Power	9v PSU input with positive sleeve (compatible with included PSU)
Audio In	Input	Audio input from Neutrik XLR-¼" combo jack
Audio Thru	Input/Output	Unbalanced minijack audio input (LINE IN) and output (LINE OUT) after 0-50dB gain preamp
Harmony	Input	1v/oct minijack harmony input modulates square/saw/sine frequencies over +/-2 octave range on 12-note equal-tempered scale
VCA In	Input	External minijack VCA input, if unpatched VCA is controlled by the envelope follower from the ACO160 chip
Aux In	Input	Minijack auxiliary audio input can be mixed in after the VCA
Mix Out	Output	Minijack output of the auxiliary audio mixer
Main Out	Output	¼" mono main output (equivalent to the aux mixer out followed by master volume control)
Pitch CV	Output	1v/oct pitch CV out (minijack)
Env CV	Output	0-3.3v output of zero-ripple envelope follower (minijack)
Gate CV	Output	0-4.5v gate CV out (minijack)
MIDI out	Output	Standard MIDI DIN output

ACO160EVK Controls

<b>Name</b>	<b>Type</b>	<b>Description</b>
Preamp Gain	Knob	Adjusts preamp gain from 0-50dB.
HPF	Switch	High-pass filter corner frequency set to 16/80/160Hz.
LPF	Switch	Low-pass filter corner frequency set to 300/1.2k/5kHz.
Gate Threshold	Knob	Tunes gate threshold from 0v to 3.3v.
Env Rate Select	8-Pos Rotary Switch	Adjusts the envelope decay rate to accommodate various instruments. Use fast rate (CCW) with fast-decaying sources like bass guitar and slower rate (CW) for sources with complex harmonic profile like violin.
Wave	Switch	Selects square/saw/sine wave for processing by VCA.
Pitch Freeze	Switch	By default, connects gate out to FTRACK input to enable frequency tracking. Can be momentarily held in opposing position to disable frequency tracking and freeze the current pitch.
Harmony	Knob	Offsets harmony shift to accommodate various CV ranges.
Aux Mix	Knob	Mixes VCA output with auxiliary audio input from Aux In
Output Level	Knob	Output master volume
Sync Freq	Knob	Adjusts hard sync oscillator generated by uC over 10-10kHz range. Setting knob fully CCW turns off the sync oscillator. Note that the sync oscillator is only active if the upper ACO Mode switch is to the RIGHT
ACO Mode (S1)	Dual Switch	Left/Left (upper/lower): Default mode, MIDI, audio both active Right/Left: MIDI off, hard sync oscillator active Left/Right: MIDI on, ACO audio output disabled Right/Right: Test mode only
Bend/Cal Mode	Switch	Sets MIDI pitch bend mode: Left = Quantize MIDI notes to 12-note equal-tempered scale; Middle = Pitch bend over +/-1 quartertone only; Right = Pitch bend over full +/-2 semitones. If CAL button is held down, generate calibration tones as follows: Left = 100Hz; Middle = alternating 100/800Hz; Right = 800Hz
Cal	Button	Hold button down to generate calibration tones as described above in description of Bend/Cal Mode switch. When button is released frequency-to-MIDI non-linearity correction calibration is performed. NOTE: Preamp gain and gate threshold knobs must both be turned fully OFF (CCW) for calibration to work correctly! Also note that this calibration was performed before shipping and is not necessary to repeat. Description is provided for informational purposes only.
Reset	Button	Global reset for micro-controller and ACO160 chip

Quick Start Guide to your ACO160EVK system

Thank you for choosing to evaluate this ACO160EVK system! Here are some basic instructions to make the most out of your ACO160EVK board:

**Basic Setup**

- 1) Apply power via the included 9v power supply unit (PSU). This unit can handle 100-240VAC at its input so will work worldwide, possibly with only a adapter for your local electric socket required.
- 2) Connect any audio input via the Neutrik combo jack (XLR or ¼" balanced or unbalanced).
- 3) Play your audio source at a comfortable volume and adjust the preamp gain until the highest green LED lights up on the peaks. If the gain is too high, the preamp will clip and the fundamental frequency detection might not work. Note that the red overload LED does not light up no matter how large the signal at the preamp out!
- 4) Adjust the gate threshold so that the gate LED turns on when no audio is being played. With plucked string instruments like guitar it may take some tuning to get the gate to differentiate exactly when a note is being played from the low-level transients that occur when you mute the strings. Try to set the gate high enough so that the LED remains on when those quiet transient events occur.
- 5) For almost all cases the HPF and LPF can be left in their default, "open" settings (HPF OFF and LPF at 5kHz). In some extreme cases changing these filtering settings can help, for example if you use a contact mic with a handheld instrument and want to filter out potential low-frequency knocks or percussive effects.

**Listening to ACO Analog Outputs**

- 6) Listen to the ACO output via the ¼" main output. To hear the dry + wet sound, connect a 1/8" patch cable between the "LINE OUT" and the "AUX IN" minijacks and adjust the AUX MIX knob to get the desired mix (fully CCW for dry, fully CW for wet). Adjust the master volume ("OUT LVL") knob to get the desired level coming out of the EVK.
- 7) Select SIN/SAW/SQR waves via the 3-way switch to hear the different ACO waveforms.
- 8) Adjust the ENV RATE SELECT rotary switch to optimize the frequency tracking for the audio source chosen. NOTE: This should be an 8-position switch, but in this version of the EVK the assembly house installed a 4-position switch by mistake. I modified the PCB so that every other rate setting is accessible from the fastest to the second slowest. Instruments with very fast attack/decay and low power in the harmonics (like guitar and bass guitar) should work well with fast envelope rate settings (CCW) whereas instruments with slower attack/decay and strong harmonics (like bowed strings) should work well with slow envelope rate settings (CW). Human voice should work well somewhere in the middle.
- 9) Adjust the "HARM" knob to hear the various pitch shift settings. Here it is especially useful to mix the dry and wet signals together so it's easier to hear what harmony interval is tuned. Note that the harmony knob is continuous, it does not give you "clicks" when moving from one harmony to another.

10) Place the ACO Mode (S1) switch with the upper switch in the right position. You may have to reset the microcontroller via the reset pushbutton switch. Adjust the SYNC FREQ knob to hear the effects of hard sync with various sync frequencies. Hard sync on the sine wave is especially juicy! Place the upper ACO Mode switch back in the left position to enable MIDI output.

### **Controlling External Synths Via CV/MIDI**

11) Patch the PITCH, GATE and ENV signals out to an analog synth of your choice and enjoy “playing” that synth with the audio source of your choice!

12) Connect the MIDI output to the digital synth of your choice via a standard MIDI DIN5 cable and enjoy “playing” that synth with the audio source of your choice.

### **ACO160EVK Calibration**

All functions in your ACO160EVK should be fully calibrated before shipment but here is a description of the calibration options:

1) DC offset at the ACO balanced input is controlled via the “OFFSET” trimpot.

2) Pitch CV 1v/oct calibration is controlled by the “PITCH CAL” and “PITCH OFFSET” trimpots. PITCH CAL is adjusted to tune the SLOPE of PITCH CV out to 1v/oct. PITCH OFFSET is tuned to set the absolute PITCH CV output as close to 50Hz = 1v as possible. Note that the PITCH OFFSET trimpot adjusts the level into a 3-bit flash ADC which sets the pitch offset to one of eight discrete steps and can be tuned as follows if 50Hz = 1v is not desired:

Fully CCW: PITCH CV – 210mV (50Hz = 0.79v, 100Hz = 1.79v)

Next step CW: PITCH CV – 140mV (50Hz = 0.86v, 100Hz = 1.86v)

Next step CW: PITCH CV – 70mV (50Hz = 0.93v, 100Hz = 1.93v)

Next step CW: PITCH CV nominal (50Hz = 1v, 100Hz = 2v)

Next step CW: PITCH CV + 70mV (50Hz = 1.07v, 100Hz = 2.07v)

Next step CW: PITCH CV + 140mV (50Hz = 1.14v, 100Hz = 2.14v)

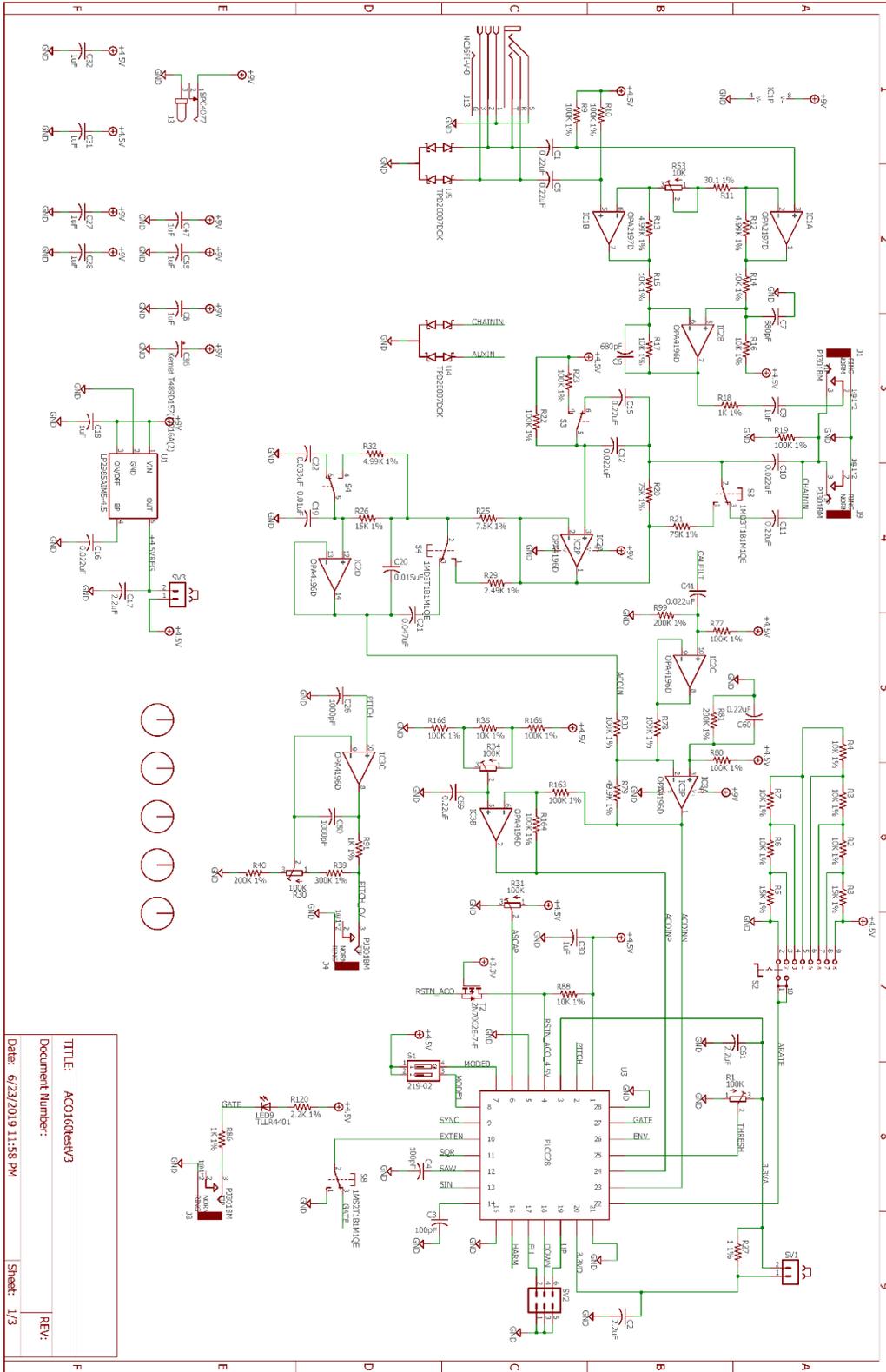
Next step CW: PITCH CV + 210mV (50Hz = 1.21v, 100Hz = 2.21v)

Fully CW: PITCH CV + 280mV (50Hz = 1.28v, 100Hz = 2.28v)

3) The HARM TUNE trimpot tunes the HARM IN CV input to 1v/oct. NOTE: This 1v/oct scale is accurate only when the HARM knob is tuned to the unison position. If the HARM knob is tuned differently the HARM IN CV scaling might differ from 1v/oct slightly.

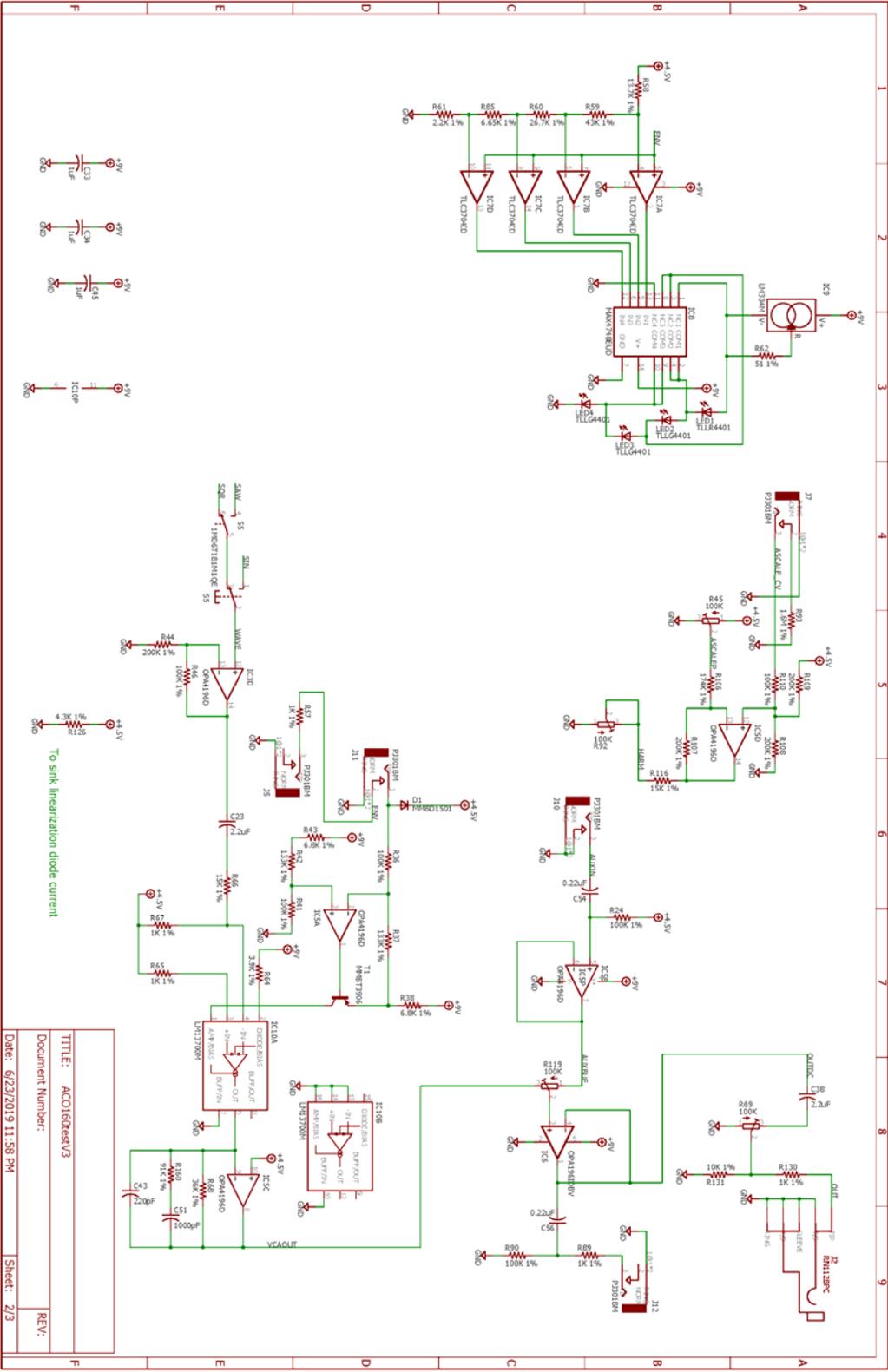
4) CAL button. Pressing this button initiates a fast three-point auto-calibration procedure to tune the ACO160 to the appropriate MIDI notes. Turn off your audio source and turn the preamp and gate threshold knobs fully CCW to ensure calibration can be executed successfully.

5) Reset button. If you try to convert an especially challenging audio source to MIDI, it can result in some stuck notes. Pressing the RESET button should send an “All notes off” command and resolve any such stuck note situation.



TITLE: ACO160EVK\_V3  
 Document Number:  
 Date: 6/23/2019 11:58 PM  
 Sheet: 1/3  
 REV:

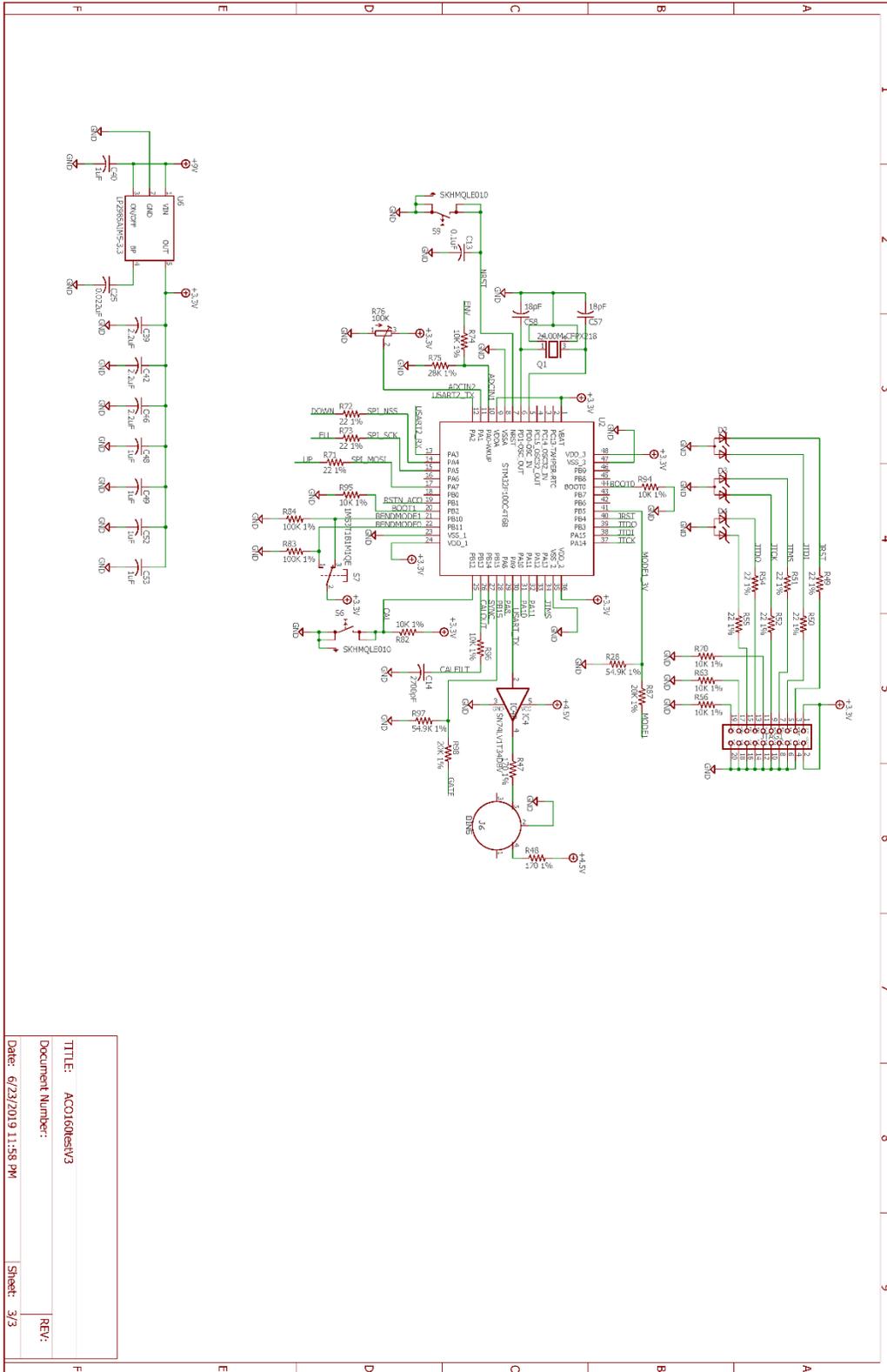
ACO160EVK Schematic – Page 1



TITLE: ACO160Rev3  
 Document Number:  
 Date: 6/23/2019 11:58 PM  
 Sheet: 2/3

ACO160EVK Schematic – Page 2





TITLE: ACO160EVK3  
 Document Number: REV:  
 Date: 6/23/2019 11:58 PM Sheet: 3/3

ACO160EVK Schematic – Page 3